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THE PRIMARY ACTION OF THE GALVANIC CURRENT.

IT INCREASES THE AMOUNT OF OZONE IN THE BLOOD AS SHOWN BY CHEMICAL TEST OF THE BLOOD IN THE ARTERIES—WITH OUR THEORY OF ANIMAL ELECTRICITY.

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Schönbein in drawing his conclusions regarding the nature of ozone, assumed that oxygen was capable of three distinct conditions, viz.: ozone, electro negative, antozone, electro positive and neutral oxygen, which, as its name indicates, has no polar distinction, but could be polarized and depolarized at will.

Of these three so-called forms of oxygen, the investigations of the observers since the day of tne great Basle chemist have much changed our views. To-day we admit the existence of only two forms of oxygen—ozone and neutral oxygen, and for the sake of elucidation we give you the graphic construction of the molecule as we believe it to be :

$$\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O} = \text{Ozone.}$$

$$\overset{-}{O}\,\overset{+}{O} = \text{Neutral oxygen.}$$

Assuming, as he and the aftercoming observers did, that oxygen in its free state was neutral, and it so proved to be, he reasoned and it is within the pale of all researches, even up to our own time, that as soon, or rather as we have found it, just before this oxygen

enters into combination with either organic or inorganic substances in the presence of moisture it becomes polarized.

Carrying these conclusions into the field of physiological chemistry, he became convinced that the corpuscles like phosphorus were possessed of the power of polarizing the oxygen in the lungs, and further of splitting up the molecules and rearranging them in the form of ozone. His idea was that ozone existed in the blood, that it was the vital oxidizing agent by means of which the recuperative changes in the tissues were wrought, yet the years of careful work he devoted to searching, failed him in finding the slightest trace of ozone in the blood.

In his later years he became equally emphatic in his assertion that the resolution of ozone—its oxidation was so rapid that in the blood and the moistened tissues surrounding the capillaries where the real respiration is accomplished it would be next nigh impossible to chemically detect the presence of ozone by the most delicate test. He even went so far as to doubt its existence in the blood, that is to say, he believed that it was ushered into existence and was used up in performing its function so quickly that it was not possible to chemically isolate it, that in the blood of the capillaries—presumably the radicals, although he does not so put it—where the pressure conditions are such as to allow of the free interchange of the gases of the blood with the tissue elements, ozone no longer existed.

Like many other great minds Schönbein was right in many of his claims, but in many other of his theories he allowed himself to fall into error, for in justice to those who come after him to study this question of the physiological significance of ozone, and with no discredit to his greatness Schönbein left much to be cleared up and explained. The ever changing and improving chemical facilities and knowledge make this task far more easy. With the advantages afforded by the chemistry of his day, Schönbein accomplished an Herculean task. That famous physiologist His who had grown up in shadows of Schönbein's laboratory and influence also failed to discover ozone in the blood.

At the very time His was engaged in his futile efforts, Alexander Schmitt was at work upon the same question—ozone in the blood.

We need not rehearse the details of Schmitt's methods, suffice it to say his experiments were elaborate and carefully made, and showed beyond doubt that ozone existed in the blood; but the quantity, apparently, was very small.

Not long afterwards Kühne, improving on Schmitt's tests,

proved that ozone existed in the blood in readily appreciable quantity, and the question was forever settled in the affirmative. *

Kühne concluded, and his deductions were not far from approximating the truth, that the red corpuscles greedily absorb ozone under the natural formation of carbonic acid, and decompose water as free oxygen is liberated.

Our experiments on the blood with the galvanic current are in a line with those of Kühne and Schmitt, only a short step in advance of those observers, a mere completion of their unfinished tasks. Whatever value the results we have obtained may have, there can be no doubt that the galvanic current applied to the living body, whatever else its action may be, increases the amount of ozone both in the corpuscle and the plasma.

Before entering into a rehearsal of the details of our experiments, let us briefly touch upon the physiology of the blood and the function of its gases; for here it was that we suspected the seat of first physiological action of the galvanic current, and here, too, we were led to trace to its source, animal electricity, and observe its function as we suppose it, in the human economy.

THE BLOOD—ITS GASES AND SOLIDS.

The gases in the blood, the carbonic acid, the nitrogen and the oxygen, which interests us in particular, need not be gone into at length.

The oxygen in the blood exists in two forms. First, that which is held in solution by the plasma, and second, that which enters into combination with the constituent elements of the corpuscle.

The first variety commands our attention for the reason that to all appearances, the galvanic current first acts upon this freely dissolved oxygen and which naturally, therefore, first undergoes the transforming change from O_2 into O_3.

With a single exception, that of defibrinated blood, the blood obeys Dalton's well known law of the absorption of gases by liquids. In vacuum 100 volumes of blood give up a trifle over 72 volumes of gas, of which in arterial blood 20 volumes, upon analysis, consist of oxygen, while in venous blood the volume is reduced to between 8 or 10.

The plasma simply holds the oxygen in solution, while the haemoglobin, which by actual weight makes up 90 per cent. of the

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* **Kühne & Scholz,** ***Virchow's Archiven*****, 1865.**

dried corpuscle, enters into partial combination with the oxygen, although we have observed, and the observations are in keeping with those of other observers, that the oxygen in the haemoglobin is in such a loosely-combined state, that it readily solves its bonds of union, and under the slightest provocation goes over to the other elements for which it has affinity as soon as the pressure conditions of the plasma are changed so as to permit of a loosening of its bonds.

Plasma, or to be more accurate, fresh serum, will, upon exposure to the air, absorb no more gas than ordinary water under similar conditions, some three volumes; defibrinated or whipped blood, however, contrary to what might be expected, takes up considerably more. This will suffice for the behavior of the gases of the blood. Now a word about its solid constituents.

In general, in the plasma they are serum-albumen, globulin and crystallizable fatty and nitrogenous matter which, as we shall endeavor to show, are rendered more diffusible by this very transformation of oxygen into ozone, caused by the polarizing action of the existing animal electricity of the body, and rendered even more diffusible by the action of the galvanic current.

In the larger vessels, for example, the carotid artery which we have chosen as the seat of our experimentation, not only because it is accessible and convenient, but rather because it is a direct branch of the aorta where both the plasma and corpuscles are equipped with all the oxygen they can carry, the blood is charged to its full capacity with those elements which it is commissioned to give up to and upon which the tissues depend, particularly oxygen.

All physiologists agree that in these large vessels carrying arterial blood the haemoglobin in the corpuscle is in the form of oxyhaemoglobin which signifies simply that the haemoglobin has entered into partial combination with as much oxygen as it can hold, and that it is ready to transfer this oxygen to the tissues as soon as the oxygen of the plasma has become exhausted, and the pressure conditions become so reduced as to permit the giving up of the gas.

This occurs in the capillaries. Until these are reached the pressure of the oxygen in the plasma restrains the haemoglobin from giving its oxygen. Here, in the liquid moistening the febrillæ of muscle that surround the terminal capillaries where the transfer of oxygen in reality begins, the tension of the oxygen is almost nil, since the tissue elements are steadily taking up the gas from the

lymph surrounding them, and the plasma continues to give up oxygen through the walls of the capillaries until the tension falls too low for it to longer do so; then it is that a portion of the oxygen of the haemoglobin is freed and is dissolved in the plasma to take the place of that oxygen which it has given up and which in turn has passed out into the lymph on the other side of the capillary wall. This interchange continues until the pressure of the oxygen in the lymph equals that of the oxygen in the plasma, by which time the venous system of capillaries, the return circulation, has been reached.

One of the strong indications of the action of the galvanic current on the blood is the probability that it facilitates this transfer of oxygen to the tissues in active form, both chemically and physically. By rearranging the atoms of some of the molecules of oxygen in the plasma the volume of the oxygen held in solution is reduced, and the oxygen of the haemoglobin is at once transferred to the plasma instead of being doled out, as it were, to suit the constantly varying pressure changes that go on as the blood completes its circulatory round. This being the case, the transforming process is undoubtedly ushered into existence through the polarizing property of the animal electricity, of which we shall speak further on.

How far chemical change is wrought upon the diffusible solids of the blood by the generation and presence of such an increased amount of ozone, we are unable to make precise answer and we leave it to the thoughtful investigation of those observers who may take interest in our work and who are blessed with a more acute knowledge of physiological chemistry and a more completely equipped laboratory than it is our good fortune to possess To our mind there seems little question of the occurrence of just such a change as we have described. Our analyses thus far, have remained within the sphere of quality; it remains for others to continue in the more exact line of quantity. Reasoning by analogy, the galvanic current acts precisely upon the oxygen in solution in the plasma as it did in the jar filled with O_2 through which Schönbein passed the current and observed its transformation into ozone.

There is but one possible action of the ozone on the blood. It must hurry on the transfer of the oxygen to the tissues., call into existence the oxidation of those constructive elements which the tissues require for their revivification. Doubtless, these changes are more extensive than we have been able to determine.

OTHER FACTORS TO BE CONSIDERED.

The experiments of Guy-Lassan should teach us a valuable physiological lesson. From his laboratory we feel that we can carry them over to that storehouse of chemical energy—the human body; and observe changes corresponding to those he observed in his jars filled with gases possessed of great affinity for one another which, however, remained quiescent and inactive until he prodded them with the stimulus of a galvanic current, which, as it passed through the gases, spurred into action, or awakened, as it were, their slumbering affinities, polarized their molecules and ushered into life the new something, the result of the three great potent factors—polarization, chemical action and affinity. We have tried to impress upon you the importance of these three conditions, for upon them depend all the chemico-physiological changes—in short, all changes that go on within the human body.

We have observed them time and again in the course of our experimenting, and we have subjected them singly and together to the most rigorous test of verification.

Our observations point to the one conclusion, and that is, that chemical action, the feeder of life, cannot go on unless there is present an electrical force, an energy that can polarize the molecules of the combining elements and prepare them for combining action. Affinity, catalytic force, the phenomena of contact in themselves are impotent without that ever preceeding factor—molecular polarization.

It is the metabolism, the anabolism, the katabolism, the all, and more were it possible, of that cardinal nourisher of tissues, that feeder of life, the blood.

Animal electricity, and the important part it plays, we will reserve for a later chapter, and pass over to general details of our experiments upon the blood of the living animal in its normal state and under the stimulus of the galvanic current.

PRELIMINARY TESTS.

For a period of 72 hours before entering upon the examinations, we hung in various portions of our laboratory slips of specially prepared paper, saturated with a solution of the iodide of starch, and others moistened with tinct. guiac. These, as we all know, are acknowledged tests upon ozone. We kept the papers under careful observation, examining them in strong light at intervals of an hour, and as there was no evidence of a reaction at the end of the allotted

time, we were justified in concluding that the atmosphere of the laboratory was free from ozone and the other gases which act upon starch and guiac. Next we directed our attention to nitrous compounds in the air, for the reason that they—if they exist in the slightest appreciable quantity—give us a reaction very much like that of ozone, and their presence must be excluded in order to give any sensitive test for ozone practical chemical value.

The test we applied for nitrous compounds is an extremely useful one, unusually sensitive, and we give its chemistry for the benefit of those who may desire to repeat our experiments. It is named Gries's Test, after its discoverer. He observed that in sulphanilic acid and naphthylamine we have a reagent which acts on nitrous acid, but not on H_2 O_2 or O_3. This discovery Gries made while engaged in studying the action of diazo-benzene-sulphonic acid on naphthylamine.

He obtained his diazo-benzene-sulphonic acid by treating sulphanilic acid with nitrous acid, and calls attention to the extreme delicacy of the reaction, minute traces of nitrous acid sufficing to produce a dark red color in the presence of dilute sulphuric acid. The colored substance formed is an amido-azo derivative of the formula

$$* C_6H_4 \ (So_3H) \ N = N \ C_{10}H_6NH_2$$

called azo-amido-naphthalene-benzene-sulphonic acid.

Prof. Slosvay,† of the Polytechnic School at Buda-Pesth, increases the sensitiveness of the reaction by substituting acetic for sulphuric acid, and he can detect with it nitrous acid in aqueous solution in a dilution of 1 part nitrous acid to one thousand million parts of water.

The formula of the test is : H

$C_6H_4 \ NH_2 \ (So_3H) + C_{10}H_7NH_2 + No_2 = C_6H_4 \ (So_3H) \ N = NC_{10}H_6NH_2$ sulphanilic acid and naphthylamine.

We availed ourselves of Slosvay's modification of Gries's formula.

A tank of a capacity of 50 gallons at a pressure of 30 pounds was filled with air from the laboratory. The air was sent through an air meter which registered one litre per minute, and from this into a test tube containing distilled water, through which it was allowed to bubble for 10 minutes and then tested.

There was no immediate reaction, and only after half an hours' standing did we observe a tinge of color ; so faint, however, as to

* Ber. d. Chem. Gesell., 12, 426, 15, 2191.

† Bulletin de la Societé Chimique de Paris, Sept. and Nov., 1889.

be almost imperceptible in ordinary light. In order to see it, we were obliged to back the test tube with pure white filter paper and hold it the sun-light.

In view of the delicacy of Slosvay's reaction, it was fair to assume that the quantity of nitrous acid in the air was so infinitesimally small that for practical purposes it could have no effect in interfering with the subsequent tests for ozone.

10 litres of oxygen were treated in the same manner. The oxygen was first subjected to two washings in distilled water without giving any reaction to the nitrous acid test. The remaining 40 gallons which were afterwards liberated in the laboratory were washed in caustic soda and dried with sulphuric acid (C P) and bubbled through distilled water. There was no reaction with Gries's test, thus showing that the gas was absolutely pure and free from admixture with nitrous and other gases.

This concluded the preliminary testing. The object of the careful analyzing of the air of the laboratory as you may already divine, was to devise means of testing for ozone in the open, and to avoid the less satisfactory method used by Schmitt, who treated his ozone in a balloon from which the oxygen had been removed as nearly as possible to do so, by means of carbon dioxide, or handling it in a similar glass receiver, from which all air had been exhausted, which was the manner in which Kühne conducted his experiments.

For several days work was suspended and resumed again Monday, Aug. 21. On that morning we were treated to a genuine surprise, that caused us to ponder for a while. Dr. J. C. Dittrich, who, perhaps, ranks first among the authorities on ozone in this country, and who kindly assisted us in the chemical portion of our work, prepared several specially sensitive test papers, which, on being moistened with distilled water, at once gave a reaction. The air of the laboratory was evidently charged with ozone, and we were at a loss to account for its presence. Speculation was soon set at rest when we recalled the violent thunder storms of the Sunday and Saturday before.

The ozone was the result of the intense static discharges of those days, and the amount that had been generated by the great Pluvius certainly was enormous and beyond measure. For that day and the three succeeding ones, work had to be deferred, with all the preliminary testing for naught.

On the following Thursday, on resuming operation, no ozone or

nitrous acid was detected in the laboratory. The preliminary tests on being repeated gave results as already stated.

TESTING FOR OZONE IN THE BLOOD.

A rabbit that had been well fed for a week was the subject of investigation—it was a big animal, in fine spirit, and weighed four pounds three ounces. It was brought into the laboratory, and both carotids cut through and the blood collected in a sterilized glass receiver. In all, sixty grammes were extracted and defibrinated with sterilized glass rods. The operation requires nine minutes, and the fresh serum was subjected to test.

The serum was diluted with distilled water, in the proportion of one part of serum to four of water.

With the iodide of starch an immediate reaction was observed in the open air, and the same reaction faint at first, but gradually deepening in blue color, showed under a bell glass.

Testing with guiac tincture of the officinal strength, which we reduced by adding an equal volume of absolute alcohol, responded more quickly to reaction of ozone. The blue ring around each drop of blood was marked and sharply defined. The same reaction continued when the test was made under the bell glass, and gradually approached its maximum of intensity at the end of half an hour, when, to all appearances, the ozone became completely exhausted.

The fibrinous clot, with the entrapped corpuscles, was likewise tested, and gave a far more distinct and marked reaction than the serum.

It was evident at a glance that the corpuscles contained a far larger amount of ozone than the plasma.

The remainder of the defibrinated blood, about forty grammes, which had been kept in a well-covered jar, was next subjected to electrification for five minutes. ~~The resistance of the fluid was measured and found to be 9,000 ohms.~~

A galvanic current of ten volts and fifteen mil. amperes was sent through the fluid. The electrodes used being strips of platinum an inch long and three-eighth inch wide.

In six seconds the meter dropped to eight mil. amperes, and the registration which was recorded at the end of each minute read as follows:

1 minute	7	mil amperes.
2 "	5	"
3 "	4.5	"
4 "	3.75	"
5 "	3+	"

Testing with iodide of starch and guiac tincture showed the unmistakably increase of ozone. The rings around the drops of blood were of deeply blue hue, and the reaction continued on with much greater rapidity than was the case of the unelectrified blood. As quantitative test was out of question, Dr. Dittrich and my colleague made an approximation of the intensity of the action by comparing the rapidly deepening ring of blue with the chromatic scale, given by Dr. Fox, in his exhaustive work on ozone. They carefully noted the change of color as it progressed, availing themselves of the most advantageous light facilities, and agreed upon the estimate that the amount of ozone adequate to such reaction must be in the neighborhood of, at the lowest calculation, at least two and one-half times greater than the amount indicated by the reaction in the case of the unelectrified blood. The clot deposited around the electrode at the positive pole gave a more animated reaction, the ring of blue almost approaching indigo, showing a most marked increase over the former reaction.

Standing by itself this test of the blood outside of the body signifies but little, for it is the blood that circulates through the living organism unimpeded with which we have to deal and in which physiological conditions alone can be of any value in the study of the action of the galvanic current. Yet withal, when taken in connection with the tests that were afterwards made, the observations form an important link in the chain of evidence that it is animal electricity which is the polarizer of the atoms of neutral oxygen both in the plasma and in the haemoglobin.

Under normal conditions the transformation of O_2 into O_3 is slow and gradual and the polarization of the neutral oxygen is proportionate to the polarizing force of the existing animal electricity.

Undoubtedly Schmitt, Houzeau, Meisner, Kühne and others were right in their assumptions, but it seems to us that they did not probe deep enough for a solution of the possible origin of this transformation of neutral oxygen into ozone within the human economy. It was due to the polarization of the atoms of the neutral oxygen, but how did it come about?

We have assumed in starting out upon the experiments the results of which form the title of the paper we have the honor of presenting to your consideration, together with the more exact details which we hope to announce at some future day, step by step, with the view of adding some light to the question, that this generation of ozone admits of a satisfactory scientific explanation.

During the years that my colleague and myself devoted to the study of ozone within the body, we have always regarded it with awe and veneration. We have woven theory after theory only to find that the strands broke precisely within the limits of the reasoning of the great observers to whom we owe all we know of ozone, and that to us as physiologists is indeed little.

That ozone can be found in the blood nourished by gases that contain no ozone is a fact beyond dispute, yet the problem of its generation is a problem that at first sight offers no easy solution.

In looking over the field of possible sources to explain this source of the formation of ozone it fastened itself upon us that one great factor that might afford an explanation had been overlooked. It was animal electricity, and we have tried to explain its function. There seems to be but one deduction to draw from the most careful observation and that is, that it is animal electricity upon which not only the polarization of the atoms of oxygen but all molecular polarization and chemical action in the body depends.

We believe that the transformation of oxygen into ozone within the body is brought about by this very animal electricity, which polarizes the neutral oxygen to such a degree that a portion of the atoms rearrange themselves, attract and repel each other under this polarizing force until we get the ozone which we detect upon analysis. The function of the ozone is apparent to all of us. It gives the oxygen increased power to form combinations with the tissue elements and promotes oxidation.

This polarization of the oxygen seems to take place just as the gas touches the tissues where the conditions are favorable to such an action and where it closes circuit with electricity in the human frame. The unaffected molecules of oxygen under the vigorous spurring of this ozone become vitalized as it were and at once begin the search for their affinities in the tissues and enter into combination with them.

The proof of this reasoning seems to us to be apparent from the fact that we have been able to appreciably increase the amount of ozone in the blood by passing very weak currents of galvanic electricity through the body, and it is the underlying theory upon which we based our experiments and which we hope to make clear to you.

Before dismissing this portion of our paper and passing over to an account of our experiments upon the blood of the living animal electrified by a current of galvanic electricity, permit us to advance

another theory which we regard as justifiable from our findings, and we do so only in the hope that it will give rise to careful discussion, for it is at variance with some of our pet physiological theories; it is

That oxygen in the blood stimulated by the polarizing power of animal electricity, and more so under the stimulus of the galvanic current enters into combination with the Haemoglobin of the corpuscles with a partial transformation into ozone, and that in loosing its combining bonds it undergoes a further partial transformation into ozone.

EXPERIMENTS ON THE ELECTRIFIED ANIMAL.

This brings us to a record of the experiment upon the living animal with the galvanic current.

The animal chosen was also a rabbit, which was prepared by being fed on fresh vegatables for several days. He was in prime condition and was allowed to run at large until he was required for use. The batteries, two of the ordinary 24 cell medical machines of the Edison-Lelande pattern were used. The batteries were carefully tested cell by cell and the current measured with both volt and mil ampere meter. A coil of a resistance of 400 ohms which had been placed in the circuit was removed after the measurement had been taken and we decided upon a current of a strength not to exceed 40 mil amperes.

Two cuts about half an inch apart were made into the skin of the animal and into these and for a distance into the body of the muscle, the platinum electrodes used in the previous experiment were inserted and a current of 20 volts turned on. The meter showed 44 mil amperes. This dropped quickly down to 41 mil amperes. The reading of the meter during the 5 minutes that the current flowed was as follows :

1	minute	40.5	mil amperes.
2	"	38.	"
3	"	37.+	"
4	"	35.8	"
5	"	35.—	"

At the end of five minutes both carotids were cut through and 35 grammes of blood were drawn into a sterilized glass vessel and defibrinated as before with sterilized glass rods.

It was observed that the blood was of a brighter scarlet hue than that which flowed from the arteries of the unelectrified animal.

Exposure to the air while the process of defibrination was going on did not affect the bright tint. Defibrination too, was not so easily affected and the fibrin slowly gathered around the rods.

Seven minutes after the blood was shed a gramme of the fresh serum was diluted with two grammes of distilled water and subjected to test with both guiac and starch iodide. The reaction in both instances was almost immediate, a trifle more active with the guiac. The ring of blue around the drops of blood was more pronounced and much deeper and kept on deepening both in the open air and under the bell jar as had been done with the blood from the first animal killed. At the end of twenty minutes the test papers, those saturated with guiac and starch iodide, three of each variety being exposed to the air and a similar number under bell jars, indicated the termination of the action and they were taken out and carefully compared with the test records of the first experiment which had been preserved in air-tight tubes. The blue ring was, even upon the most superficial examination, found to be several shades deeper and the ring of reaction was more spreading, in some of the drops, almost half an inch wide and distinctly visible to the line of demarcation of chemical action. The fibrin also gave like results. A far larger amount of iodine had been set free in these tests than in the case of the first analysis. The quantity of ozone to give such reaction according to a most conservative calculation of both Dr. Dittrich and my colleague was estimated to be certainly three times greater than that which gave the reaction from the normal blood.

The increase in the amount of ozone was astonishing and far beyond our expections. We had anticipated some difficulty in determining the increase if it proved to be trifling, but here we were met by a quantity far in excess of what we had hoped to find in the event of the most successful termination of our searching.

The action of the current on the oxygen in both plasma and corpuscle enmeshed fibrin was evident in the transformation of a portion of it into the more vital form of O_3. That the current had accomplished this transformation, astonishing as it proved to be, was readily to be explained, but not so with the ozone in the normal blood. There was but one explanation for this, the polarizing action of the animal electricity.

OUR PLAIN VIEWS REGARDING ANIMAL ELECTRICITY.

The existence of animal electricity is acknowledged. The origin and action however are the points upon which electro-

physiologists are not quite clear. Those who have given the subject some consideration dismiss it by establishing its connection between chemical action, heat and animal electricity. They rest content in discussing the three conditions without attaching the slightest importance to the precedence of one or the other of them. Chemical action we are told evolves heat, and so tissue metamorphoses and oxidation go on. They are satisfied with the evidences of the existence of animal electricity, that it can be measured, and that it is one of the great trinity upon which life rests.

It is in view of this condition of the investigations upon this question that we approach it with much trepidation and fear lest we be charged with being too radical in our deductions; we can almost see doubt written upon the faces of many of this distinguished gathering, and we can almost hear you say, "Well, are you going to settle the question?" Settle the question or not, still we have the boldness to advance a probable solution of the problem, and we ask you to follow closely our experimentation and the deductions we have drawn and based our opinion upon.

We will not take up your time by rehearsing the observations of the various electro-physiologists who have enlightened us in animal electricity. To do so we would in fairness to all be obliged to begin with Matteucchi and so on up to the present day, without omitting a single one, for each of the observers have welded a link in the chain of result, and to leave out a link would mean to destroy the integrity of the chain.

Let us for a moment consider the observations of Dutrochet, and we may get a clue to the true function of animal electricity. He observed that if the positive pole of a battery be dipped into pure water and the negative in gum water, endosmosis continued more energetically.

Onimus later on discovered that with a reversal of this order of pole, endosmosis too was reversed. It is but fair, reasoning again by analogy, to assume that the electricity in the body exercises precisely the same physico-chemical action. We have already called your attention to the observations of Gay Lassan. Whenever the so-called catalytic action takes place in the living tissue, is it not equally fair to assume that animal electricity is the prime mover? Can there be any question that electricity, galvanic, with its electrolytic powers, the ready manner with which it decomposes the salts, coagulates albumen in the vessels of our laboratories, has a like action on the tissues and fluids of the living organism?

It is apparent, we hold, that animal electricity not only influences the whole system of nutritive operations, but also directs them.

Time and again we have electrified animals and observed that under certain conditions of electrification, the animals threw off a greater amount of urea and carbonic acid than under ordinary conditions.

Urea and carbonic acid ! and what is the significance of such an increase in the waste products ?

Nothing more than, and nothing short of increased chemical action, increased tissue metamorphosis, the increased evolution of heat ; but the electricity, the animal electricity—that remains unaccounted for.

Dutrochet and Onimus showed us the action of the anode and the cathode in endosmosis, and left us to apply it to the physiology of nutrition. Now let us do so and account for the function of animal electricity if we can. As we have already intimated, the order of action is animal electricity first, and why, because we must have polarity before we can have chemical action and its natural result, heat.

Subject a solution of the iodide of potassium to electrification and you free the iodine. Inject a quantity of this fluid into the blood of a living animal and then subject the animal to electrification, and in a very few minutes starch papers held in contact with the parts surrounding the positive pole, will indicate that the iodine is set free by the action of that pole. Note the transfer of the chemical action from the laboratory to the living body ; are the two not singularly alike ?

Unfortunately we have not been able to isolate the poles of animal electricity, and hence it is that our tests on animals similarly injected, yet not electrified, give us such indistinct reactions, that we hesitate to announce them as positive results.

Yet all this points to the one conclusion, and the one deduction, that animal electricity comes first ; that is the prime factor in all the processes of change, of chemical action, or otherwise, within the living body. That without its stimulus of polarization, no chemical action can be called into life, and consequently none can go on ; and tissue metamorphosis, which is life itself, must cease.

Before concluding, allow us a word or two upon ozone, its physiological and therapeutical value, which are not under discussion, and are hardly properly to be considered in the limits of this paper.

We have dealt with ozone generated from the oxygen within the body, and it is in this form that it plays its so important role in the oxidation of the tissues. There seems to be some doubt as to posibility of introducing ozone in its pristine integrity into the system. It may be a feat within the range of possibility, judging from the voluminous literature upon the subject that has been published only within the past year or more, yet from our experience in handling it, we prefer to regard it as an agent that performs its most useful work upon the field where it is ushered into existence, where nature calls it into life because it is needed to perform important duties.